A Watershed of Opportunity

"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land."
—Luna B. Leopold, former chief hydrologist for the U.S. Geological Survey and the son of Aldo Leopold.

Water defines life in Wisconsin. Wisconsin's landscape, history, cultures, communities, ecosystems, and economy are fundamentally shaped by water: the Great Lakes on our eastern and northern borders; the Mississippi River on our western border; a vast network of surface waters —15,000 inland lakes, 32,000 miles of perennial rivers and streams, 5.3 million acres of wetlands; and 1.2 quadrillion gallons of groundwater residing in four major aquifers. These waters interact to form an integrated hydrological system; life's essential element, our most precious resource, and an asset of inestimable global significance.

The unique importance of Wisconsin's waters confers upon us a special stewardship responsibility —for ourselves, for our neighbors, for future generations, and for the community of life that depends upon them. Through the Waters of Wisconsin initiative, (and this special issue of EE News), we have explored the many dimensions of that responsibility. We summarize here our efforts to understand the state of our waters, the challenges we face in sustaining them, and the educational and policy actions we must take to be effective stewards of our waters over the long run. ❖

Inside this issue...

Smaller Point of View

I sink slightly as I step on the expanse of sand
Which supports an entire lake full of life.
I am mesmerized as the distant sun falls.
Shimmering atop the vast, rippling surface,
Warming the waves wrapped around me.
I gaze into the glowing water,
Barely knee-high,
And take note of the minute creatures
Swimming freely about my toes,
And wish I could see the beauty
From yet a smaller point of view.

Cassandra Tuszka
Wausau West High School, 2001
2002 River of Words Contestant ❖

Wisconsin Water Facts

Did you know that of the top 10 events that shaped Wisconsin's history, the first three were borne from our water resources?

1. The great dam burst of 12,000 BC carved Devil's Lake State Park, forming the landscape we know today of moraines, drumlins and eskers.
2. When water was essential for transportation and communication, Jean Nicolet's boat landed in Green Bay in search of a "Northwest Passage" waterway leading to the Pacific Ocean. Instead, he established relationships with the Winnebago and Menominee peoples and paved the way for open trading with the French.
3. Madison is selected as the state capital due largely in part to the beauty of the "Four Lakes" area and surrounding landscape features.

To learn more about Wisconsin's other top ten historical events that shaped the state, refer to the State of Wisconsin Blue Book for 1999-2000, available through your library, school, or online at: http://www.legis.state.wi.us/lrb/bb/ ❖

wisconsin academy
of sciences arts & letters

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This issue of EE News is in celebration of 2003 as Wisconsin's Year of Water. Several of the articles are adapted from Waters of Wisconsin: the future of our aquatic ecosystems and resources, report of a three year initiative to examine Wisconsin's waters in the context of several generations with the intent of creating a framework to enhance the long-term sustainability of Wisconsin's waters. A full copy of the Waters of Wisconsin report can be found on line at http://www.wisconsinacademy.org or requested by calling (608) 263-1692 x10.

Special thanks to Shaili Pfeiffer for providing content oversight and direction, all the writers who contributed articles for the special issue, and to Carrie Morgan for assistance with editing. ❖

Water Primer: Just the facts

By Randy Hunt, U.S. Geological Survey, Wisconsin District

"When drinking water, think of its source."
- Chinese proverb

Liquid water is what makes our planet unique and is essential for life as we know it. Many ancient civilizations were located on the banks of rivers or near seacoasts. Civilizations flourished with adequate water supplies, and then crumbled when the water supplies failed. Water itself is an amazing molecule. Water is known as a "universal solvent" for its ability to dissolve many solids. It exists in three different forms (ice, liquid, and vapor) at temperatures experienced by life on Earth. Aquatic life in Wisconsin would be very different if water did not have a unique property - its solid form (ice) is less dense than the liquid from which it forms. As a result, ice floats. If this was not the case, our lakes would freeze from the bottom up and everything within the lake would freeze completely whenever the temperature got below freezing. It is hard to imagine how good the fishing would be in such a world!

Knowledge of the basic scientific foundations of water science is vital to our common understanding of how this resource works. Water has been studied for centuries, with the first measurements of precipitation taken around 2,500 years ago. The first aqueduct and canal projects date back to the ancient Egyptians, about 5,000-5,500 years ago. But water was often mysterious to the ancients. During the time of Plato and Aristotle there was much debate on where rivers obtain their water. Now we know that there is a global "water cycle" where water is evaporated from the oceans, falls to the earth as snow and rain, and moves back through our aquifers (the upper parts of the Earth that hold and transport water) and rivers to the atmosphere and ocean. While much has been learned that can be useful for understanding the Waters of Wisconsin, some myths about water have also come up from time to time. The purpose of this section is to "prime the pump" by covering some of the principles that govern water, and providing some perspective to the science and myths that surround this all-important resource.

Four Misconceptions

The great Wisconsin naturalist James Hall Zimmerman ("Jim Zim") distilled observations from 40 some years in the field to "Four Misconceptions" about our wetlands that also apply to all our Waters of Wisconsin. While many are at least partly aware of these myths, they serve as a starting point for understanding our water resources.

1. *"All water resources are alike"*

From a practical standpoint, it is desirable to lump our water resources into a few categories. But in reality there can be vast differences in the sources of water, and how vulnerable an individual lake, river, wetland or aquifer is. For example, there are over 100 types of wetlands in the United States; there are 14 wetland types in Wisconsin alone. Some are primarily rain-fed; some have significant groundwater sources. Others have important stream inputs; others do not. Lakes, streams and aquifers also have different conditions that result from different sources of water. Cold-water streams are associated with higher groundwater inflows; warm-water streams are often derived from surface water sources. Deep, clear-water lakes are often groundwater fed. Deep aquifers supply water from storage or leakage from overlying rocks while shallow aquifers supply water derived from precipitation that infiltrates the ground and other water sources (streams, lakes, wetlands). How a water resource will respond to a stress (for example, a nearby pumping well) will be different depending on what supplies its water.

2. *"Our water resources can stand alone"*

The water body can appear to be an isolated feature in the surrounding landscape. But, in reality, it is connected to the larger landscape through overland flows during snowmelt and heavy rains, and by the less visible groundwater system that underlies the land. Moreover, many animals depend on conditions on both sides of this edge during different times of their life. So, what happens on the land, even though it is not directly adjacent to the water body of interest, can still have an effect on the quality of our water resources. This connection is why we often hear about the need to protect and manage our water resources by watershed or basin. It is one of the reasons that wetlands are often called the "kidneys of the landscape." Wetlands take pulse inputs from within the basin (water, sediments, nutrients, and contaminants) and either trap and transform the inputs, or release them to the downstream system at a much-reduced rate. Thus, when we lose wetlands in a basin, it is like losing our "kidneys" without access to dialysis!

3. *"Our water resources do not change over time"*

We view our water resources being essentially unchanged since the glaciers receded 10,000 years ago. But, this is not the case. Natural erosion and deposition have cut some valleys deeper while slowly filling other lakes and wetlands. Water levels in a lake, stream, or wetland vary from year to year due to changes in annual precipitation. Human activities have accelerated many of these natural processes.

4. *"Our water resources function the same regardless of impacts"*

In Wisconsin, we have multiple uses for water and engineering technologies that allow us to modify the natural water flows. What is less known is that diverting, ponding, pumping, and using water affect the functioning of our natural water resources. One cannot expect a wetland to support rare and endangered species if its sources of water are changed by stormwater addition or nearby high capacity pumping. The water quality of a deep clear-water lake will change in response to nutrient additions from failing septic systems. Trout streams cannot support trout if its groundwater supply is limited by pavement and storm sewer interception in the basin, or sediments from improper development and agricultural practices cover the gravel spawning beds. While the quantity of function loss for a given impact is often not well understood, we should expect some loss in function.

Six Scientific Misunderstandings

These four misconceptions go hand in hand with scientific misunderstandings about our water resources. While there is some overlap with Jim Zim's ideas, it is worth elaborating the specific ideas below. Discussion of the future of the Waters of Wisconsin will be most productive if we start free of these misleading notions.

1. *"We have all the water we could ever need"*

From space one can see that the majority of the Earth's surface is covered by water. It is estimated that the volume of water on the earth is around 330 million cubic miles - enough to cover the entire Earth's surface to a depth of 1.5 miles! But, as you might expect, not all of the water is suitable for human consumption. The break down of the Earth's water supply is shown here.

Of these, usually only groundwater and surface water are considered suitable for human consumption. Even though the global percent-

age of these waters is low, this is still a large quantity of water.

In Wisconsin, we receive around 31 inches of precipitation a year, which equals 29 trillion gallons of water that fall as snow and rain. So why do we hear about possible water shortages in our water-rich state? Most of this water (around 75 percent) is transferred back to the atmosphere by evaporation and plant transpiration before it makes it to groundwater or surface water. However, even considering that most water does not make it to groundwater and surface water, there is a more subtle issue: water supply problems are not problems of amounts of water available statewide; rather, they are local supply problems. That is, water flows in the natural system in some cases cannot keep up with the local demands placed upon it. It is a problem of transport in that our ability to locally extract water exceeds the natural replenishment of water. So, while we truly have ample water in our state, we can still have water shortages in localized areas where more is being withdrawn than can be obtained from elsewhere in the natural system.

Supplies must also be put in context of current and future water use. While a person requires less than a gallon to live, our personal water usage in Wisconsin is much larger than this basic requirement, around 63 gallons per day for each person. And, if energy, industrial, and agricultural uses are factored in, our per capita usage approaches 260 gallons per day. When all this water use is put together Wisconsinites use 1.45 billion gallons of water each day!

With increasing population, recognition of water's multiple uses, and pressures on the water resources, water quantity issues will likely continue to be a topic of debate in the future.

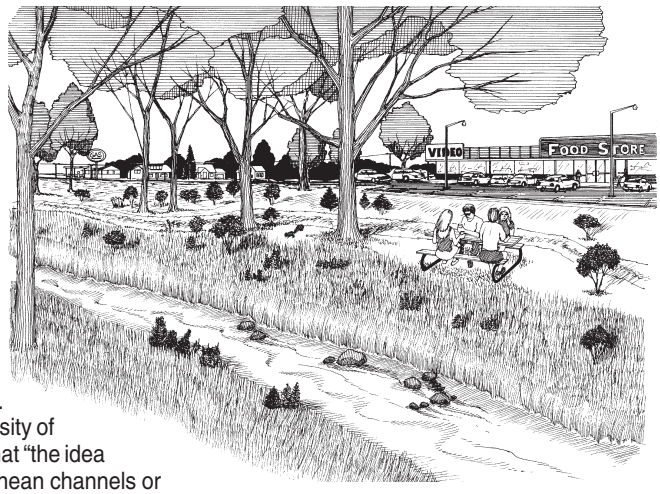
2. *"Water doesn't move"*

While it is easy to see water moving in a river or stream, it is less obvious that all water - including lake water and groundwater - moves. This movement follows well-established scientific principles that state that water moves from high to low energy. In Wisconsin, groundwater generally moves from higher areas in the landscape toward lower areas containing streams, rivers, and lakes, or toward low areas created by pumping. Surface water flows "downhill" (downstream) unless captured by a municipal or irrigation water intake.

While all water moves, it does not all move at the same rate. Where as in a stream it is not uncommon to see water moving at speeds of a foot or more per second, a speed of a foot per day is considered fast for groundwater flow! In fact, some shallow groundwater in the red clay areas of northern Wisconsin has been there since the time of the glaciers - 10,000 years ago! This leads to an important point about water resources - the rate of natural replenishment, and associated vulnerability (to contaminants), is different for different water resources.

Thus, water can be thought of this way, it is not a non-renewable resource like oil and gas, but neither is it a completely renewable resource like solar energy. Slow rates of groundwater replenishment also have real-world consequences.

3. *"Our water comes from Canada, mostly from underground rivers"*



One of the great natural scientists, T.C. Chamberlin from the University of Wisconsin, stated in 1885 that "the idea that there are vast subterranean channels or caverns in which artesian water flow like a river has been long since abandoned. These are matters of common scientific knowledge." However, these myths have surprising resiliency. In fact, most of the groundwater that we use does not come from underground rivers but comes from areas close to the wells that pump it. The quality of our surface-water supplies is controlled by the quality of the surface-water body from where it is pumped. Thus, how we use our land controls the quality of our water.

4. *"Surface water can be treated separately from groundwater"*

Traditionally, discussion and management of water is separated into groundwater and surface water components. But, in reality, nearly all surface water features interact with the groundwater system. Rather than separate components, groundwater and surface water form a continuum in our landscape that extends from areas where the water is below the ground to areas where the water is above the ground. Thus, water is linked across time and space. Most surface water can be thought of as a visible expression of the groundwater system, and much of the groundwater system can be thought of as a hidden supply to the surface water system. As a result of this interconnection, any discussion about water must include both the groundwater and surface water components.

5. *"Water can be used without any effect"*

A basic principle of water science is that water cannot be created or destroyed; what flows into a system has to flow out or the storage within the system (represented by water levels) has to change. This system response is like a household financial budget.

Any imbalance is made up by a change in lake or aquifer storage, as shown by changes in lake or aquifer water levels.

The upshot of this principle is that there is no unused water - all water is being used by some thing or someone. Because water is responsible for many of those things we find dear in Wisconsin, actions that remove, redistribute, or transform water will likely be felt by the natural system.

The ability of natural groundwater and surface-water systems to redistribute water illustrates a common misconception regarding the idea of a water budget. Indeed, water science has tried during different times in its history to address what has been called the "water budget myth." It is a common misconception that the amount of water available for use by people is equal to the amount of replenishment over a given area.

In order to assess the effects of water withdrawals a more holistic view of the water system - groundwater and surface water - is needed.

6. *"The past can predict the future"*

In the past, we could stress our aquatic systems without seeing a noticeable change in the quality of the water resource. But, now we know that there are "cumulative" effects such that the same stress applied later in time to an already stressed system can have a much larger impact.

Given these cumulative effects, how systems responded to the stresses of our ancestors may not give us a good indication of how they will respond as we and our descendants stress them.

We also know some actions cause major effects immediately, like introduction of exotic species. Invasive species can change the entire character of our aquatic ecosystems as well as our ability to use them for recreation or drinking water. Find out what species threaten Wisconsin waters on page 7.

Although there are misconceptions and misunderstandings, a scientific framework gives us the dimensions of what is possible, as well as a firm foundation from which to look at the past, present, and future of the Waters of Wisconsin. Of course, there is more than just science that enters into this discussion. Indeed, as Loren Eisley once noted:

"If there is magic in this world it is to be found in water."

Randy Hunt, U.S. Geological Survey, Wisconsin District, 8505 Research Way, Middleton, WI 53562, e-mail: rjhunt@usgs.gov ❖

Groundwater — Wisconsin's Buried Treasure

By Laura Chern, Hydrogeologist, Wisconsin Department of Natural Resources

[Did you know? If you covered Wisconsin will all the groundwater found here, it would be 105 feet deep which totals 1.2 quadrillion gallons of water.]

Much of what you love about Wisconsin - lakes, rivers and wetlands - can be attributed to the groundwater that flows beneath your feet. Groundwater, also known as Wisconsin's buried treasure, is one of Wisconsin's most important natural resources. Unless you live in one of a few large cities in Wisconsin such as Green Bay, Superior, or Milwaukee, the water you use for washing, flushing, drinking, watering and cooking comes from an aquifer. Groundwater also supplies fresh water to Wisconsin's 2,444 trout streams, 5,002 warm water streams, 15,057 inland lakes and 5,331,392 acres of wetlands. This surface water/groundwater connection is important to aquatic plant and animal species that rely on groundwater to maintain their habitats by providing them with enough clean water to thrive.

Groundwater protection challenges are complex and vary by land use and location within the state. This article looks at the threats to groundwater and what families and schools can do to use groundwater wisely while protecting it from harmful pollutants that affect the health of people and the environment. ❖

The Groundwater/Surface Water Connection

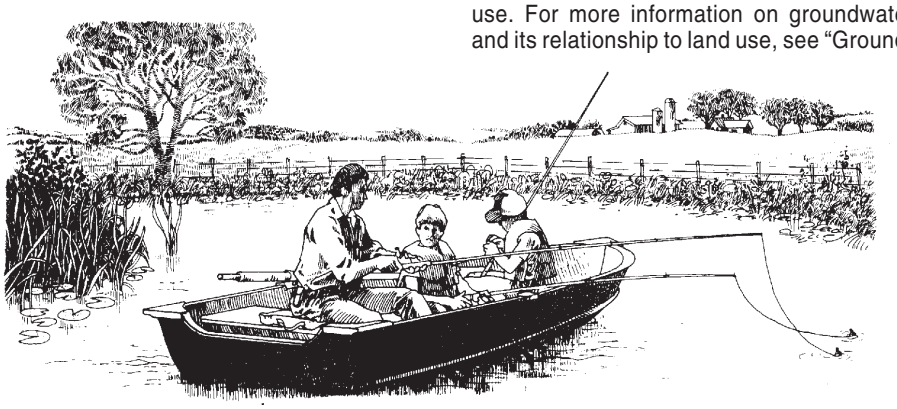
When you look at a lake, river or wetland, it appears to be an isolated body of water within the landscape. In reality, surface water is almost always connected to groundwater. Rivers and lakes are commonly at the receiving end of groundwater flow that originates as rainfall on nearby upland areas in the landscape. Groundwater provides a river's base flow, defined as low flow in rivers during periods of no runoff. When groundwater flows into surface water, it influences the amount of water in a stream; it's chemical composition, and stream temperature. All of these factors in turn affect fish habitat and the plant communities they rely on. Groundwater, surface water, the landscape and habitats are all connected. Because these connections are unique in different parts of the state, Wisconsin manages water, land, and wildlife resources within hydrologic units called basins.

Debunking Two Myths

Two of the more resilient but untrue myths about groundwater are that 1) drinking water comes from a far away, pristine place such as Canada or Lake Superior; and 2) groundwater has been underground for thousands of years. While it is comforting to believe that groundwater has been protected from modern pollutants or that it comes from a place far from human influences, the truth is, most groundwater comes from areas close to the wells that pump it. In general, this water fell as rain or snow a few decades or years before it was drawn up the well. It is important to know that how we use our land, what you and I put on its surface, influences the quality of our groundwater right now. (Read more about these myths and misunderstandings on page 2.)

Threats to Groundwater

Groundwater protection is complex because land use, water use, and geology affect groundwater quality and quantity. You name it - gasoline, fertilizer, pesticides, and animal waste - if humans use it, it may show up in groundwater. Urban and rural areas present different groundwater problems. Activities in urban areas that threaten groundwater quality include industrial and municipal waste disposal, winter salting on roads, parking lots, sidewalks and driveways, and storage of petroleum and other hazardous chemicals. Animal waste, septic systems, fertilizer and pesticide applications are primary sources of contamination associated with rural land use. For more information on groundwater and its relationship to land use, see "Groundwater: Protecting Wisconsin's Buried Treasure" (PUBL-DG-055-99).



Geology, the rocks and sediments that make up the aquifers in which groundwater travels, also determines the quality and quantity of groundwater. Natural contamination can come from minerals existing in soils and rocks which dissolve in groundwater. Some minerals, such as calcium and magnesium are beneficial to health. Other contaminants such as arsenic and radionuclides (radioactive elements) have been found at risky levels in Wisconsin's drinking water. Addressing these problems can be difficult if no other source of water is available. For more information on arsenic and other naturally occurring contaminants in Wisconsin, see the Department of Natural Resources' Drinking Water and Groundwater Web pages at: http://www.dnr.state.wi.us/org/water/dwg/

Geology also influences groundwater quantity. If water cannot travel through less permeable aquifers, it is not available for use. Cities and towns in the north central and northeastern part of Wisconsin receive the most precipitation in the state but they are underlain by crystalline bedrock, a type of rock notorious for yielding only small quantities of water.

There is growing concern about the availability of good quality groundwater for municipal, industrial, agricultural and domestic use as well as adequate base flow for surface water bodies even in those parts of Wisconsin that have had plentiful groundwater supplies in the past. Natural shortages of groundwater have occurred due to weather conditions and geologic conditions. With changes in the global climate, there will be changes in groundwater quantity.

Human activities also cause water shortages. Groundwater withdrawals in the Lower Fox River Valley, Southeastern Wisconsin and Dane County have caused declines in groundwater availability. Urban areas require large quantities of groundwater to serve their populations. When large areas of land are paved over, there is less space for water to seep into the groundwater and recharge our aquifers (see "Location is Key" on page 8). In rural areas, high capacity wells pump millions of gallons of water for crop irrigation. Private wells in rural areas can be affected by this seasonal pumping. ❖

A Little History

Wisconsin has a long tradition of protecting public health and drinking water quality.

1903 - The State Laboratory of Hygiene was founded in response to the prevalence of waterborne illnesses such as typhoid fever, cholera, small pox, diarrhea and gastroenteritis. At that time, most drinking water came from lakes and rivers, which were also used for waste disposal. Because wastewater treatment was not very sophisticated, many lakes and rivers became contaminated and drinking water supplies received little treatment. At the turn of the century, the death rate from diarrhea and gastroenteritis was about 11 per 1,000 people. Typhoid fever claimed 1 in 1,000.

1919-The Legislature passed Chapter 144 Wisconsin Statues which gave the state control over public water supplies. To provide safe drinking water, municipalities had to follow sanitary engineering principles and construct wastewater treatment plants. Drinking water had to be analyzed for water borne illnesses at the State Laboratory of Hygiene on a regular basis.

1930s-Wisconsin's leadership set a national standard for protecting private wells and home water supplies by regulating private well construction. Well drillers must be licensed and participate in continuing education programs.

1974-Wisconsin adopted its first drinking water standards to minimize bacteria and other pollutants, the same year the federal Safe Drinking Water Act was enacted.

1974-The Wisconsin Supreme Court ruling in the State of Wisconsin v. Michels Pipeline Construction, Inc. case, gave the state the ability to regulate groundwater for the common good of all citizens.

1984-Wisconsin's groundbreaking and comprehensive "Groundwater Law," Chapter 160, of the Wisconsin Statues passed. All state agencies involved in groundwater protection must enforce numerical standards. The standards define the level at which groundwater contamination must be cleaned up and are based on human health, environmental health and public welfare considerations.

Things for students and teachers to do at school and home:

- Teachers can use the quiz below to test their students' knowledge and understanding of groundwater.
- Learn about your water supply system and how landuse planning is protecting the source of your drinking water. (http://www.dnr.state.wi.us/org/water/dwg/gw/whp.htm)
- Brainstorm ways to keep chemicals from getting into the ground.
- Talk about disposal of pet waste. (http://www.state.nj.us/dep/watershedmgt/pet_waste_fredk.htm)
- Learn about ways to conserve water such as low flow toilets, aerators on faucets, and limiting lawn watering. (http://www.h2ouse.org/)
- Talk about the effect of salting sidewalks and driveways. (http://www.dnr.state.wi.us/org/caer/ce/eek/earth/carcare.htm)
- Talk about the impacts of applying pesticides and fertilizer on lawns. (http://clean-water.uwex.edu/pubs/yardcare/rethink.pdf)
- Talk about the need for abandonment of unused wells. (http://www.dnr.state.wi.us/org/water/dwg/wellaban.htm)
- Learn how a septic system works and is maintained and talk about what things should not be put into a septic system. (http://www1.uwex.edu/ces/pubs/pdf/B3583.PDF)
- Talk about nutrient and pest management strategies on a farm. (http://ipcm.wisc.edu/)
- Request Wisconsin's "Groundwater Study Guide" packet. This award winning material is a curriculum development guide primarily for middle school earth science teachers (adaptable to older and younger students), informal education settings and the general public. The guide comes with a packet that includes copy-ready student activity sheets, overhead masters, one large (32" x 48") and 10 small (11" x 17") Groundwater and Land Use in the Water Cycle posters and a copy of Groundwater: Protecting Wisconsin's Buried Treasure. A copy can be obtained from the DNR at (608) 266-0821. ❖

Activity: Groundwater Quiz

1. Where does groundwater come from?
   A. Rainfall and melting snow
   B. Underground rivers

2. How many people in Wisconsin get their drinking water from groundwater?
   A. 50 Percent
   B. 70 Percent

3. How fast does groundwater move?
   A. It flows like a river or stream.
   B. A few inches per year to a few feet per minute.

4. What can you do to help protect groundwater?
   A. Recycle used waste oil.
   B. Don't use more lawn chemicals than necessary.
   C. Dispose of hazardous and household chemicals properly.
   D. All of the above.

5. Where does groundwater flow when it comes out of the ground?
   A. Lakes, rivers, and streams.
   B. Groundwater stays underground and does not come to the surface.

6. How often should you test a private water well?
   A. At least once a year.
   B. At least once every five years.
   C. Someone else will test it for me.

7. What can make groundwater unsafe to drink?
   A. Leaky landfills.
   B. Leaking underground storage tanks.
   C. Failing septic systems.
   D. All of the above.

8. Can you drill a well anywhere and get good groundwater for drinking?
   A. Yes, groundwater is about the same everywhere.
   B. No, the quality can be very different from place to place.

9. Why should I be concerned about groundwater protection?
   A. It might be the source of your drinking water.
   B. It could cost lots of money to clean up the groundwater.
   C. Groundwater can make me sick if it is contaminated.
   D. All of the above.

10. Where can you get more information about groundwater?
   A. Your local library.
   B. The Department of Natural Resources.
   C. The Environmental Protection Agency Safewater Web site.
   D. All of the above. ❖

Reprinted with permission from the Wisconsin Department of Natural Resources' EEK! Kids' Web site where you can find more information on water. Visit: http://www.dnr.state.wi.us/eek/ ❖

Answers: 1.A; 2.B; 3.B; 4.D; 5.A; 6.A; 7.D; 8.B; 9.D; 10.D

Discovering the World through Wetlands

By Derek Strohl, Program Director at the Wisconsin Wetlands Association

[Did you know? Wetlands make up 15 percent of Wisconsin's land surface at 5.3 million acres.]

It seems to me that the best thing about teaching in a wetland is that the teacher has as much to learn as the students, and the students can be the ones discovering new bits of information for the rest of us. There are many reasons for this. Obviously, every wetland is unique. When you take your students to a wetland, they will not be studying just wetlands; they'll be studying a particular wetland. Sure, we know that wetlands are places where there is a lot of water, but where does this wetland get its water? And where does the water go? And, what's growing in the water while it's here?

Wetlands form an intersection of sorts between all of nature in Wisconsin. They're positioned at the boundaries between waterways and uplands. We find them both in the woods and out in the open grasslands. Wetlands hang out in the low areas where water just sits, and sits, and sits, and they spring up on hillsides, where water seeping out of the rock provides just enough moisture for some skunk cabbage to push its way up through the February snow. Some wetlands disappear in late summer, leaving only watermarks on trees as evidence that they ever were there.

Finally - and because of the wide distribution of wetlands - wetlands are also an intersection between all of the natural sciences. Studying the geology of a local wetland area helps you and your students to discover where the water comes from. Understanding meteorology shows you why it is that the water disappears for part of the year, as your wetland becomes water vapor, which becomes a cloud, which becomes another wetland, perhaps in New England. Surveying the insects in a wetland can reveal why certain plants thrive there, and that can explain why certain other animals make their homes in that wetland.

The most exciting part of learning in wetlands is finding out, not just what the wetlands are, but what the wetlands are doing. By studying the water quality in and around a wetland, we can see what the wetland is doing to provide clean water for wildlife, the adjacent stream, or the aquifer below that is watering the nearby city. By watching the water level in a wetland following rain or the snow melt, we can appreciate what wetlands are doing to keep the water level from rising in our basements. By investigating the wetland at several times of the year, we learn that the frogs don't just appear one day and leave a few months later. Rather, they lay their eggs; the eggs hatch (the ones that don't get eaten); the tadpoles grow (the ones that don't get eaten); and the frogs crawl out (the ones that didn't dry up in the vanishing pool). The frogs eventually hop away to spend their summer in the woods hundreds of meters away from the wetland, and, once again, we're reminded that wetlands are connected to the groundwater, the soil, the uplands, and the sky. That's what is so great about taking your students to a wetland: when they understand the wetland, they understand the world. ❖

Wetland Resources

Project Wetland Watch Network. The Wisconsin Wetlands Association is an education and advocacy group for the protection and promotion of wetlands. It coordinates a network of volunteers who monitor wetlands and engage in various wetland protection activities. It also promotes public awareness of wetland preservation issues through field trips, workshops, exhibits and other public programs. The association Provides a slide show on Wisconsin wetlands and maintains a database of educational resources and contacts. Cost: Volunteer for free, membership fee $20 individuals, $30 families. Wisconsin Wetlands Association, (608) 250-9971, e-mail: wetlands@execpc.com

Wisconsin Coastal Management Program. Promotes awareness of coastal issues: wetlands protection, non-point source impact to Great Lakes, and public access to Great Lakes. September is Coastal Awareness Month. Program is for youth, adults, communities, nonprofit, and decision-makers. Contact Dea Larson-Converse, Department of Administration (608) 267-7988, e-mail: larsed@mail.state.wi.us ❖

Water for Sale

Water is a precious and scarce resource, so why isn't water and the rights to it bought and sold on the open market? Increasingly, it is. For example, the sale of bottled water is a large and growing business...and we pay more per gallon for it than we do for gasoline. But we buy and sell water in other forms (beer and soda, for example). Water courses through our economy much as it courses through our landscape.

That fact raises complex economic, political, and ethical issues. In Wisconsin, we've seen this issues arise as such high-profile issues as the Perrier Company's proposal to bottle groundwater from south-central Wisconsin and periodic proposals to withdraw or divert Great Lakes waters. New international trade agreements may affect the governance and legal status of water in unprecedented ways. These and other issues raise profound questions about society's role in conserving and managing water resources, and about the relationship between public and private interests in water.

Water Watch

Students can watch for these growing issues in the media and discuss and/or debate them in class.

1. *Privatization* - the transfer of public water supply and treatment systems from municipalities to the private sector and private companies selling the water to its customers.
2. *Commodification* - efforts, mostly in the private sector, but also in government, to purchase, produce, process, market, and distribute water.

These issues raise fundamental questions:

- To whom does Wisconsin's water belong?
- How much can an individual use?
- Who has the right to sell it?

By investigating Wisconsin's public trust doctrine and common law, students can learn who has rights to our surface and groundwater resources and their use. For background information on this, refer to the Waters of Wisconsin of Wisconsin report. ❖

Aquatic Alien Invaders

These invaders are actually exotic plants and animals that have been introduced to our state from other countries or habitats on purpose or by accident. More invaders arrive as our global trade markets expand. Today there are 161 exotic species thriving in Wisconsin's waters, ranging in size from single-celled algae and zooplankton to mollusks and fish. They can cause all kinds of problems for plants and animals that have always lived in our state. Learn more about each of these species so that you and students can pick aliens out of a crowd, learn how to identify impostors, and help exterminate these invaders before they take over! Here's a starter list for students to begin investigating:

- Alewife
- Eurasian Carp
- Eurasian Watermilfoil
- Purple Loosestrife
- Rainbow smelt
- Reed Canary Grass
- Round Goby
- Ruffe
- Rusty Crayfish
- Sea Lamprey
- Spiny Water Flea
- Three Spine Stickleback
- Water Milfoil
- Zebra Mussel

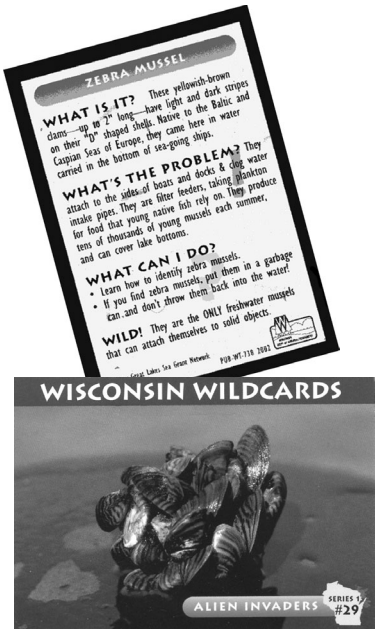
Educational Resources

Aquatic Nuisance Species Attack Pack. A self-contained teaching kit designed to help high school students teach younger students about invasive species. The kit includes maps, brochures, watch cards, overheads, PowerPoint presentations, specimens and activities. No cost. Contact Phil Moy at Wisconsin Sea Grant (920) 683-4697, e-mail: pmoy@uwc.edu

Exotic Species Compendium. Developed by the Great Lakes Sea Grant Network. The classroom resource, Exotic Species Compendium of Activities to Protect the Ecosystem (ESCAPE), is a collection of 36 hands-on multidisciplinary activities that incorporate experiments, art, music and games. ESCAPE introduces students to issues of exotic (non-native) aquatics: spread and transport, harmful effects posed, importance of environmental knowledge and responsibility of each student as an environmental steward. http://www.iisgcp.org/edu/escape/

Wisconsin Aquatic Invasive Species Wildcards. By the Wisconsin Department of Natural Resources. Small trading cards identify 13 species that are invading our waters, describe the problems they cause, include action tips and "wild" facts. Order a sample set of the 13 cards or classroom sets of 30 of individual species including: Alewife, Curly-leaf Pondweed, Eurasian Water Milfoil, Purple Loosestrife, Rainbow Smelt, Round Goby, Ruffe, Rusty Crayfish, Sea Lamprey, Spiny & Fishhook Waterfleas, Threespine Stickleback, White Perch, and Zebra Mussel. Contact Mandy Beall, (608) 267-3531 or e-mail: mandy.beall @dnr.state.wi.us

Wisconsin Purple Loosestrife Biological Control Program. Control this invasive weed with less dependence on herbicides. Citizen "cooperators" can propagate tested and safe biocontrol insects for release into local purple loosestrife infestations. Raise beetles outdoors from April through July. Beetles are effective on many sites. Designed for organizations, adults, teachers and youth (grades 6-12). Cost: inquire with program. Contact Brock Woods, DNR, (608) 221-6349, e-mail: brock.woods @dnr.state.wi.us ❖



Waters of the World

Living as we do amid abundant freshwater, Wisconsinites are liable to forget how fortunate we are. People around the world - by some estimates, one-half of the global population - are not so well-off. Instead, they face chronic water shortages, and the water they do have is often unfit to drink. The quantity, quality, availability, and sustainability of water are now the focus of increasing attention at the international level.

Three main causes lie behind the growing water shortages globally.

1. World population growth. There is no less water in the world, but the water that exists is shared among more people. China, Egypt are especially vulnerable.
2. Water supplies have been abused. Almost 50 percent of the world's fresh water is polluted. Many citizens of developing countries, and in the cities of Mexico City and Bangladesh, are poisoned or at risk.
3. Water shortages from increased per capita consumption as nations shift from mostly agrarian economies to mixed economies. From 1900 to 1980, the population of the U.S. increased three-fold, we industrialized, and per capita use of water quadrupled. As a result, we used 11 times as much water in 1980 as we did in 1900. The same will probably hold true for developing countries as they improve their standards of living.

Many regions around the world depend upon non-renewable water sources - waters captured in the ground eons ago and not recharged in current times. Libya, and Saudi Arabia will likely exhaust their supplies in 50 years.

Compounding the problem is the fact that, worldwide, more than 250 river basins are part of two or more countries. Water treaties between riparian countries exist in only about 64 of these. Africa, Israel, Syria, Jordan, and the Palestinians all have issues of shared water sources and differing cultural and political ideals across boundaries.

Keeping abreast of our water resources and water troubles around the world can help Wisconsinites prepare for potential difficulties for our own water resources. Wisconsin, despite our abundant waters, has situations similar to those found elsewhere in the world. We, too, are experiencing overdrafts of groundwater, high levels of arsenic and other contaminants in drinking water, and increasing international interest in the freshwater of our state and region. However distant the world's water problems and challenges may seem, they are ours as well.

Keep your eye on the International Watersheds Conference which is held at University of Wisconsin-Stevens Point College of Natural Resources' (CNR) Global Environmental Management (GEM) Education Center. They hosted the second annual international watershed seminar this past June. Participants came from Russia, Mexico, Israel, Turkey, South Africa, Botswana, Armenia, Tanzania, Peru, Samoa, Jordan, Ecuador, Paraguay, the Philippines and the United States. They gathered to share water issues and problems in their local communities and learn about watershed planning and management for sustained resources management.

For more information, visit the GEM Web site at: http://www.uwsp.edu/cnr/gem/ ❖

Location is Key

By Lisa Gaumnitz, Wisconsin Department of Natural Resources' Water Public Affairs Manager

Location, location, location. We all want to live in a nice place and many Wisconsinites live near water, but this ideal is also emerging as the key to understanding how to protect streams and minimize the damage development can cause.

What is your watershed address? Start with identifying the stream or tributary that is near you.

A watershed is an interconnected area of land draining from surrounding ridge tops to a common point such as a lake or stream, which will join with a neighboring watershed. All lands and waterways, and you, are located in one watershed or another.

What is the connection between humans and watersheds? Well, scientists in Wisconsin and elsewhere have learned that land use in areas that drain to streams strongly affects the quality of streams.

Li Wang and John Lyons of the Department of Natural Resources found in their study of 47 small southeastern Wisconsin watersheds that even areas with low levels of suburban development can inflict severe damage. They've documented significant declines in the number of fish (41 percent) and fish species (15 percent) as an area urbanizes.

Now Wang and Lyons have taken that work one step further. They've examined land use, fish habitat, and fish community data in those same small watersheds and discovered that "development near a stream has more impacts than development farther away." Fish communities were more impacted when "urban land uses along the stream were within 100 meters and in areas immediately upstream within a 1.6 to 3.2 kilometer radius than urbanization father away."

"Non-urban land uses near the stream, like farming, forest land, government land, etc., had little influence on stream quality," and the "effects of connected imperviousness [in a suburban area] were overwhelming.

"Connected imperviousness" is the term that scientists and water quality experts use to talk about rooftops, sidewalks, streets, parking lots, roads and other surfaces that do not allow rainwater to soak into the ground but instead runoff the surface. These surfaces are directly connected with waterways when rainwater on a driveway flows into a street, into a sewer system, and drains eventually into a stream.

The pollutants carried in the runoff - and the sheer amount and speed of runoff produced by an impervious area — causes several problems:

- Runoff water has no chance to be absorbed into the ground and naturally filtered, where it can help recharge groundwater supplies. Instead, it runs directly into a lake or river, carrying with it all the pollutants it's picked up along the way - oil, pesticides, heavy metals, road salt, fertilizers and pet waste.
- During thunderstorms or when snow melts, the runoff creates a burst of water that erodes stream banks, sending sediment into the stream that harms water clarity and quality and alters habitats. It floods the river, bringing even more sediment and debris into the water, and overwhelming the fish and aquatic creatures that live in the stream.
- During dry times, many streams nearly dry up or become stagnant when it doesn't rain for extended periods of time, further harming fish and other aquatic creatures.

Researchers across the country agree that a tipping point of sorts occurs when greater than 8 to 12 percent of the land in a watershed is connected impervious surfaces. Small increases in urbanization above this range are linked with sharp drops in the abundance and diversity of fish, and in the year-round flow of water in streams. The Wisconsin researchers' works suggests trout streams may be even more vulnerable to development, with the range reaching down to 6 percent.

Science in Action

Wisconsin research findings and a computer model are starting to help communities continue to grow while protecting high quality streams. These tools help communities understand when certain development proposals just might affect stream quality, and guide them in trying to offset such damage. Detention ponds that store runoff and establishing green space or leaving undeveloped areas at least 50 meters wide along streams are some of the steps communities can take.

Scientists are focusing on "high priority resources and making sure [they] do everything possible to reduce the amount of water that runs off the surface of parking lots, roofs, and other impervious surfaces and increase rainwater infiltration into the ground." ❖

Finding Your Watershed Address

Learn more about your watershed through the following helpful educational resources.

Lake Michigan River Basins. Through river basin information cards, learn about your watershed including: the location, size, human population, recreation, wildlife, plants, ecology, environmental concerns and priorities for the watershed. The following cards are now available, please contact the DNR Basin Water Team Leader to order:

Lakeshore River Basin, Vacant, (920) 448-5126
Lower Fox River Basin, George Boronow (920) 448-5126
Milwaukee River Basin, Sharon Gayan, (414) 263-8707
Sheboygan River Basin, Vic Pappas, (414) 229-0862
Upper Fox River Basin, Rob McLennan, (920) 424-7894
Upper Green Bay River Basin, Doug Rossberg, (715) 582-5022
Wolf River Basin, Dan Helf, (920) 492-5841

Milwaukee River Basin Poster Map. Milwaukee River Basin is defined as the total land area that drains to the Milwaukee Harbor and includes many smaller watersheds like the Kinnickinnic and the Menomonee Rivers. The Milwaukee River Basin is located in portions of 7 counties in southeastern Wisconsin, and it is home to approximately 1.3 million people. The Milwaukee River Basin map will help students increase their level of awareness about the correlation between land use, human activities and river habitat quality. The maps were produced using the WISCLAND Land Cover database, which was produced by interpreting satellite imagery. The map includes vignettes that discuss how people use the land and how this affects our surface water and groundwater. Activities and lessons that accompany the map can be found on their Web site. These activities are designed for middle school-age students to help students gain an appreciation for the integral tie between the land use practices and natural resource quality. Visit: http://clean-water.uwex.edu/milwaukee/index.html and click on "Map Activities."

Protecting Our Watershed. By Earth Force, Inc. This activity binder is for grades five through ten and encourages projects to develop and implement watershed improvement action plans. A teacher's guide outlines the process and contains key concepts and tools. Four posters and activities sheets are included. Available in Spanish. Cost: $65 plus shipping and handling. Contact Earth Force, Inc., 1908 Mount Vernon Ave., 2nd floor, Alexandria, VA 22301, (703) 519-6877, or visit: http://www.earthforce.org

Wade Into Watersheds. By Adopt-A-Watershed. Students will learn how water supports living things and how humans affect water quality. Activities focus on the importance of water quality and ways students can protect it. Among the curriculum supplements included are: "Where Does Your Water Come From? The Source Water Book"-Water Education Foundation; "Aquatic Habitats: Exploring Desktop Ponds," GEM Guide-UC Berkeley; "Give Water a Hand"-University of Wisconsin; "Water Wisdom"-Alameda Office of Education; and "Hands On Save Our Streams"-Izaak Walton League. http://www.adopt-a-watershed.org/matrix/wiw.htm ❖

Use the activity "Where Does the Water Run?" on page 9 to help your students understand their watershed address and the flow of water within that watershed "neighborhood." ❖

Activity: Where does the water run?

Grades: 5-8

Subjects: Mathematics, Science, Environmental Education

Objective: Students will describe relationships among precipitation, runoff and aquatic habitats.

Method:

Students will (1) measure and calculate the area of a study site, (2) calculate the volume and weight of water falling on the study site (3) determine specific and annual rainfall and runoff, and (4) trace the course of water to aquatic habitats.

Materials:

Writing materials, meter or yardsticks, long piece of twine with marks every yard or meter, rain gauge, local rainfall data; OPTIONAL: calculator, a trundle wheel, which is a wheeled device for measuring linear surfaces. Contact local surveyors or other organizations for the availability of trundle wheels in your area.

Background:

Developing an understanding of precipitation and runoff is an important part of understanding the water cycle. Rainfall is one form of precipitation and is one way water re-enters aquatic habitats. Once rain falls upon a surface, water begins to move both laterally outward and vertically downward. Lateral movement is runoff and it finds its way into streams rivers and lakes. Vertical movement seeps into the soil and porous rock and recharges groundwater supplies.

Runoff waters are necessary to renew the many aquatic habitats that depend on the inflow of water for continuity. Inflow supports aquatic life by preventing lakes from shrinking because of evaporation and by preventing streams from going below minimum flow levels.

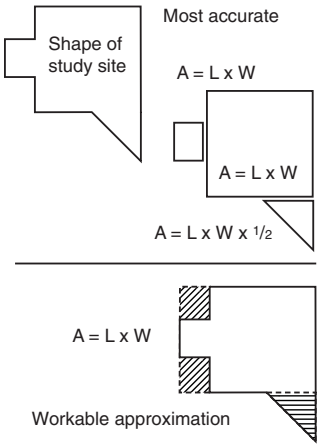
Runoff is the dominant way that water flows from one location to another. It is in runoff that many pollutants find their way into moving waters. These types of pollutants are known as “nonpoint sources.” Garden insecticides, automobile oils and transmission fluids, paints and exhaust and such are washed by runoff into streams, rivers lakes and oceans. Eventually, this water becomes part of an aquatic habitat.

Runoff is also responsible for the erosion, transportation and deposition of sediments scoured from the land’s surface. Substandard land practices along with development often leave bare ground ready for the topsoil to be washed away. Paving and compacted soil can reduce an area’s water absorbing ability, thereby increasing runoff. Reduced absorption rates can adversely affect vegetation and groundwater recharge.

In this activity, the students calculate both the volume and the weight of rainfall and consider relationships between rainfall and runoff, including effects on wildlife and the environment.

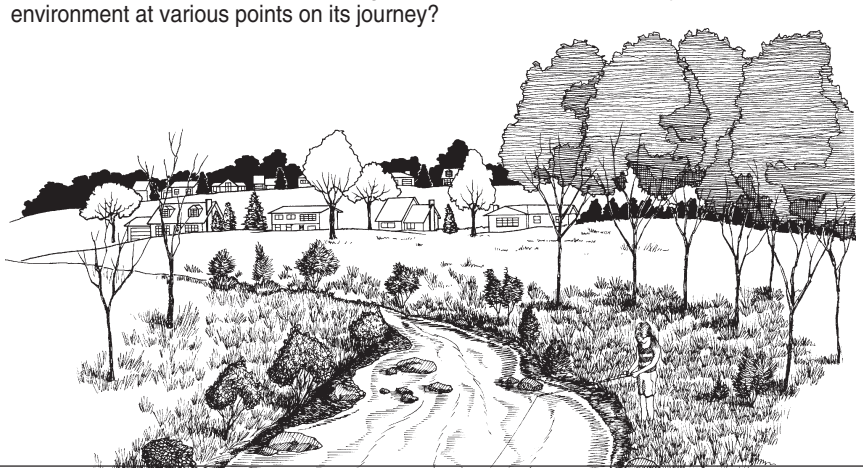
Procedure:

1. Determine the total area of the study site. For this activity, the outer dimensions of the property will be sufficient. There is no need to subtract the area of the buildings because it is assumed that rain falls on them as well.
   The formula for calculating area is: Area = Length X Width
   Note: See the extensions to this activity for metric approximations.
   The length and width of the study site must be measured. The students can use a tape measure or length of twine. The main difficulty with calculating the area comes from irregularly shaped study sites.



2. Once the area of the study site has been established, the next step is to determine the amount of rain that falls in the area. Three options are possible:
   - Calculate the annual rainfall using information from resource agencies, e.g. weather bureau, soil conservation services, local meteorologists, local newspapers)
   - Using a rain gauge, measure the amount of rain over a period of time.
   - Calculate the amount of rain that falls in a given storm.

   When the students have decided on a way to measure the amount of rain that falls during a specified period of time, ask them to calculate the amount. This calculation provides the students with a value for the depth of rainfall on the land surface.
3. The next step is to calculate the volume of rainfall. For example, suppose the area of the study site is 50,000 square feet and the annual rainfall is 6 inches or .5 feet.
   The volume of rain would be
   50,000 (SQUARED) FT x 0.5 FT OF RAIN = 25,0000 FEET (Cubed) of rain
   The volume of rain is 25,000 cubic feet (675) cubic meters of rain
4. Knowing the volume, the students can now calculate the weight of the rain. Water weighs 62.5 pounds per cubic foot, thus the weight of rain is:
   25,000 ft (cubed) x 62.5 lbs/ft(cubed) = 1,562,5000 lbs.
5. All measurements and calculations in this activity are intended to impress on students that there are remarkable volumes and weights of water moving through the water cycle. Even short periods of rainfall produce amazing amounts of water. All water that the students measure eventually finds its way to a wildlife habitat. A major issue of concern is how humans affect the quality and quantity of water that eventually reaches aquatic habitats. Consider and discuss the following questions:
   - Where does the water from rainfall go when it leaves the study site?
   - How much water is absorbed by the different surfaces on the study site?
   - What types of potential pollutants does the water come in contact with?
   - Where is the location of the nearest wildlife habitat that receives the site’s runoff?
   - How do people use the water between the time it leaves the site and arrives in the wildlife habitat?
   - What are some of the positive and negative effects that the water may have on the environment at various points on its journey?



continued on page 10

Activity: Where does the water run?

continued from page 9

Extensions:

1. Obtain a map of the study site from your school or organization and check it against the accuracy of the one made by the students. Make a copy of the study site map, then use the original map and plot runoff routes on it. Check periodically during rainstorms to identify the drainage patterns. Try to find a way to estimate how much water is draining in specific places.
2. Place a rain gauge on the grounds and measure actual amounts of rain. Repeat your calculations.
3. The contamination of groundwater is also an issue. How might water in the groundwater table or aquifer become contaminated and potentially pose a threat to human health? To the health of other animals, including wildlife? Identify as many possible sources of contamination to groundwater and runoff in your community as possible. What can be, or is being done, to reduce or eliminate these sources and their effects?

Evaluation:

1. Describe at least two relationships among aquatic habitats, precipitation, runoff and surface water.

2. Identify two human activities that have affected the quality of runoff.

3. Identify two human activities that have affected the quantity of runoff.

4. Identify two ways that runoff can affect humans.

5. Identify and describe two ways that runoff can affect aquatic wildlife.

6. Write a short list of steps to protect the quantity and quality of runoff water.

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Sustaining Wisconsin's Waters

People in Wisconsin, and throughout the world, are coming to realize that water cannot be taken for granted. We are awakening to the strong links between water and our progress toward a more peaceful, prosperous, secure, and socially just world.

Wisconsin, though only a small part of that world, has been and should continue to be a leader in this effort. Wisconsin's bounty of freshwater and the richness of its aquatic ecosystems are assets of global significance. However, our waters face a variety of short- and long-term challenges to their integrity, beauty, and abundance. In striving to address these challenges, Wisconsin's citizens can again assert the commitment to conservation that binds our generations together over time and across our landscape.

In recent years, the concept of sustainability has emerged as a way of addressing the interrelated needs of people and ecosystems. Sustainability, in this case, implies…

A commitment to protecting, managing, restoring, and using Wisconsin's waters in a manner that ensures the health of our aquatic ecosystems while securing their cultural, economic, and public health benefits for future generations.

In Wisconsin, the sustainability of our waters is closely connected to our understanding of water as a shared resource. Our state has a strong cultural and legal tradition that recognizes the public interest in all the waters of the state. The citizens of Wisconsin firmly believe and actively support the view that we all share responsibility for stewardship of the state's waters. We also recognize that Wisconsin's waters are part of larger hydrological cycles and systems, and that our actions affect human and natural communities elsewhere. These facts imply that we have responsibilities that extend beyond our boundaries.

One outcome of the report is the development of a general statement of principles, or a checklist, that can be used to help foster more effective water policies, conservation actions, and stewardship investments involving water in Wisconsin. The principles, found on page 11, are intended to provide guidance, raise questions, stimulate discussions, and identify future directions in policy.

Of course, all Wisconsin's citizens make daily decisions that affect water. Perhaps no single statement can address all the values, realities, requirements, and concerns involving water in Wisconsin. However, the Waters Of Wisconsin participants believe that this statement, prepared in the spirit of Wisconsin's long-standing conservation ethic, can help strengthen the foundation for a sustainable water future.

Editor's Note: the full statement of principles can be found in the WOW report. ❖

Using Principles in the Classroom

For educational purposes, the checklist/question format of the principles is used here to help educators and students put them directly into action in the classroom.

Please note that in applying the principles, not all will relate to each decision at hand and that some are more relevant at different phases of decision-making and implementation. Sustainability is an ongoing progress towards establishing harmony between human needs and environmental quality.

Educators could use these principles, or criteria, to evaluate existing water education programs and develop curricula that focuses on local waters, while combining science, history, literature, and other subjects. Students could also use them to evaluate state and local water-related decisions and actions made by conservation groups, politicians, business, city planners, the school board, and the media's coverage of water issues.

Activity:

Help test these principles, here's how your class can participate in the process:

1. Find a water related decision in your community. This may be a decision from the municipality relating to water supply or wastewater; a decision relating to water recreation; a decision relating to the management of a near by river, lake or groundwater supply involving state, county, local government or businesses; or a decision relating to property development near waterways or stormwater management.
2. Then answer each of the checklist questions found on page 11 as they relate to the decision.
3. Determine how the outcome of the decision would be (or would have been) affected if the sustainability principles had been used.
4. Finally, using this experience and process, answer the questions: "Would these principles help decision makers make decision that would better protect our waters, why or why not?" and "What would make them more useful."
5. Report both a summary of the test decisions used and students thoughts on the utility of the principles.

If you have questions, contact Shaili Pfeiffer at (608) 263-1692 x21, or reports on test cases can be mailed to Shaili Pfeiffer, Wisconsin Academy of Sciences, Arts, and Letters; 1922 University Ave.; Madison, WI 53726. ❖

Sustaining Wisconsin's Waters: A Checklist of Principles

Use the following checklist to evaluate decisions being made about water. Answer the following questions by starting each one with the following phrase -

Does this decision...

Water Values

- ❑ 1. Recognize the value of Wisconsin's waters for the biological diversity and ecosystems they support; the spiritual, aesthetic, and cultural benefits they provide; and the human goods and services they yield?
- ❑ 2. Recognize that the connection between Wisconsin's waters and its people extends across generations?
- ❑ 3. Reflect an ethical commitment and personal responsibility to the health of our waters on the part of Wisconsin's citizens?
- ❑ 4. Ensure fair and equitable access to water of sufficient quality and quantity for basic uses and enjoyment?
- ❑ 5. Reflect a responsibility to avoid water uses that cause excessive, unreasonable, or irreparable harm to other people, future generations, and other forms of life?
- ❑ 6. Encourage and support the active involvement, participation, and leadership of Wisconsin citizens at the local community and watershed level?
- ❑ 7. Respect the values and traditions of the state's diverse cultural groups, while recognizing their common interest in healthy waters?

Water Connections

- ❑ 8. Recognize that Wisconsin's waters are connected to larger ecological systems and cycles, and contribute importantly to their healthy functioning?
- ❑ 9. Recognize and address connections between Wisconsin's aquatic and terrestrial ecosystems, and between Wisconsin's atmospheric waters, surface waters, and groundwater?
- ❑ 10. Demonstrate awareness of the basic importance of watersheds and water basins?
- ❑ 11. Conserve the diversity and function of aquatic ecosystems by maintaining, enhancing, and restoring the physical connections of our waters to the fullest extent possible?
- ❑ 12. Treat Wisconsin's waters as a medium in which aquatic organisms, materials, and compounds are commingled and transported?
- ❑ 13. Address the connections between issues of water quality and water quantity?
- ❑ 14. Ensure the health of Wisconsin's waters across the full spectrum of landscape types as they flow between wild, semi-wild, agricultural, rural, suburban, and urban areas?
- ❑ 15. Recognize Wisconsin's important contributions to the healthy functioning of ecosystems and watersheds beyond our state boundaries?

Water Policies

- ❑ 16. Accord with Wisconsin's traditional public trust doctrine, and appropriately balance the public interest in the state's waters with private rights?
- ❑ 17. Reflect a comprehensive, coordinated, and appropriately scaled approach to the management, use, restoration, and conservation of Wisconsin's waters?
- ❑ 18. Achieve better coordination across jurisdictional boundaries and among different levels of government?
- ❑ 19. Rest upon a foundation of interdisciplinary knowledge and integrated approaches to entire water systems?
- ❑ 20. Draw on the most reliable scientific knowledge available on water status and trends?
- ❑ 21. Recognize both the market and non-market values of water, and strive to acknowledge the full costs and benefits of varied water uses?
- ❑ 22. Address and correct economic forces that externalize costs and encourage wasteful or harmful use?
- ❑ 23. Encourage, support, and reward actions that conserve water and protect and restore the state's aquatic ecosystems?
- ❑ 24. Discourage inefficient use of water and the degradation of aquatic ecosystems?
- ❑ 25. Recognize that there is no "one size fits all" policy response to our water challenges, and instead encourage innovative adaptations?

Water Management and Stewardship

- ❑ 26. Support water education opportunities?
- ❑ 27. Use available information on water, the source and destination of the waters we use, and changes that may occur in the process of using them?
- ❑ 28. Take into account the impact on our water of the size of our human population, our consumption habits, and our patterns of land use?
- ❑ 29. Strive to be pro-active rather than reactive, responding to long-term challenges to the health, integrity, and diversity of Wisconsin's waters before they become acute problems?
- ❑ 30. Promote water conservation at all times, and not just during times of water shortage?
- ❑ 31. Encourage, in the face of uncertainty, cautious and conservative use of Wisconsin's waters?
- ❑ 32. Seek constantly to identify and meet new water information needs in order to reduce uncertainty and improve our ability to make wise management decisions?
- ❑ 33. Strive to protect and where possible restore natural hydrologic functions, native biological diversity, and ecological integrity?
- ❑ 34. Adopt watershed and water basin approaches in water management and planning?
- ❑ 35. Encourage flexible and adaptive management of Wisconsin's waters in order to respond to unpredictable changes in climate, ecological interactions, and social and economic conditions?
- ❑ 36. Promote and provide for continuous water monitoring and assessment?
- ❑ 37. Encourage the continual development and adoption of innovative technologies to improve water conservation, education, monitoring, remediation, and restoration?

❖

Looking Ahead: Envisioning Wisconsin's Water Future

By Ken Wiesner, Wisconsin DNR and Shaili Pfeiffer, Wisconsin Academy of Sciences, Arts and Letters

A glimpse of the future was present at the Waters of Wisconsin forum last fall. Fifty high schoolers from six Wisconsin communities shared their stories of how they're stepping up as the stewards and decision-makers of the water resources they'll inherit.

Through school-based efforts ranging from cleaning up Milwaukee's beaches to monitoring water quality in a small Cambridge-area watershed, these students and their teachers are investigating and solving water challenges in their own backyards.

But there's a critical need to engage even more young people in considering Wisconsin's future. It's up to educators and students across the state to jump in and help chart a sustainable course for managing Wisconsin's water resources.

"The students at the forum were excellent examples of high school students that learn and contribute back to their communities. They provided leadership to begin addressing their watershed problems," said a statewide natural resource educator attending the forum. He also stressed that, "We need increased opportunities and resources for students to get involved in their community's environmental challenges."

What issues are youth addressing today? Students from Loyola Academy in Milwaukee have taken action to protect local beaches where they play and swim. High school students educated elementary teachers and students about the local watershed, its importance, and steps for protection. More than 800 students have participated in clean-ups at five local beaches. The Loyola students also helped the elementary and middle school students record garbage collection data and report the results to the Center of Marine Conservation.

New Auburn High School students have been active at local, state, and national levels in an interdisciplinary Lakes Project since 1996. One project involved the students in raising and releasing purple loosestrife-eating beetles and measuring the impact that they have had on the purple loosestrife found in a local watershed. Students also produced several educational publications that addressed lake management issues, safety, and exotic species. One unique aspect of the project was the interdisciplinary nature of the activities. Science, social studies, art, and writing were just some of the subject areas students touched upon during their community projects.

Cambridge High School students presented their nationally recognized water monitoring projects and activities. Other participating high schools included Plymouth, Sheboygan South, and Madison Edgewood High School.

Get Ready, Get Set

The Waters of Wisconsin report outlines the types of issues and skills society, and youth, will need to be prepared to address as future decision-makers.

"Wisconsin's waters are constantly changing. Their current state is the result of countless decisions made over the last 150 years. Some decisions consciously took into account the future; others did not. Building dams/removing dams; draining wetlands/restoring wetlands; dumping effluent into public waterways/passing pollution control measures; drawing drinking water from deep aquifers, shallow aquifers, or surface waters; cutting forests/replanting forests; plowing fields up-and-down or along the contour; introducing non-native carp and reed canary grass; - these and a thousand other actions have been based on calculations of public and private good, with long-term consequences that were sometimes anticipated, sometimes unexpected."

"The future of the waters will reveal our ability to address multiple forces, understand synergistic change, gather and use the best scientific information, build in a "safe margin" of error, and respond flexibly to change as it occurs.

"The future can be either well considered or poorly considered. Because we do think about the future, because we act on what we think, and because our actions have consequences, we are obligated to do so with as much knowledge and imagination as we can bring to the effort."

—From the Waters of Wisconsin Report

Knowing what we know - and what we don't know - about Wisconsin's waters, what can we say about the future? How will our aquatic ecosystems change? What forces will determine the quality and quantity of water one generation, or seven generations, hence? What effect will this generation's decisions and policies have on that future?

Charting a Course

The students and adult forum participants examined the above questions in ways that open imaginations, combine varied perspectives on water, and shed light on current needs and opportunities. Although we cannot know the future, we can think about it in ways that help us to better understand our choices.

The report outlines a series of principles to help guide decisions in the face of uncertainty, and recommends that Wisconsin citizens, as an informed public, develop policies that take long-term concerns into account." (See page 11 for a list of the principles.)

"...the ability to think more critically about the future of water in Wisconsin is essential." Our society's adaptive capacity is enhanced by efforts that span several generations, building a base for the continuing dialogue and thinking necessary for successful, future-oriented decision-making.

Educators are in a unique position to help engage our younger generation in important, long-range issues like Wisconsin's water future. Generating interest and having fun with water science [facts, exploration, monitoring], discussing impacts of actions and cause/effect, developing scenarios and thinking about the future, all help to build the base of knowledge that will contribute to a sustainable future.

The Waters of Wisconsin participants believe that educators have an important role in helping the next generation to become adept at thinking about the future, envisioning sustainable environments, projecting impacts, investigating causes, and making good decisions based on solid information. The skills of gathering and interpreting data, critical thinking and problem solving, and taking action in their community are important for today and the future.

Footnote: This article provides a rationale for how and why Wisconsin policy makers, educators and citizens should think about the long-term future. It also offers a series of storylines as examples of how "future thinking" can highlight key issues, forces, and relationships that affect water; and suggests ways in which we can improve the adaptive capacity of our communities, institutions, and policies.

Other contributors to this article include: Al Stenstrup and Lisa Gaumnitz, Wisconsin Department of Natural Resources; and Mary Pardee, University of Wisconsin at Stevens Point. ❖

Dive In and Get Involved

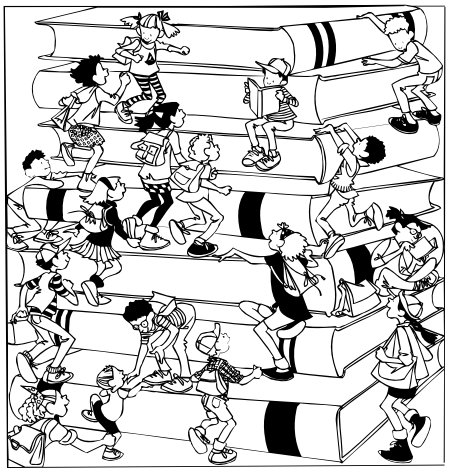
Do you want to get your students thinking about the future - exploring ideas related to possible, probable, and preferred futures; or ethical concepts like who the earth belongs to - present or future generations? Below are some curriculum and activity resources for you to use in your classroom.

Wisconsin Year of Water Web site. By Wisconsin Department of Natural Resources at: http://www.dnr.state.wi.us/org/water/division/yow/education.htm

Find suggestions for water education topics and activities. The site contains information and links to a host of educational resources and contacts that can help educators and students to get involved with water-related topics. Some references for other future-oriented programs are included below.

Education for Sustainable Future. By the Concord Consortium. This project has developed a curriculum focused on sustainability with modules for K-12 including lessons on the theme "Thinking about and Affecting the Future." Units focus on sustainability in a variety of contexts (including water) with a main emphasis of how today's choices and decision impact the world's future. Visit: http://csf.concord.org/esf/index.php

Inventing the Future: Activities to help students learn about future and sustainability in the Third Millennium. By the Canadian Parks and Wilderness Society. Activities in this curriculum guide focus on the distinction between possible, probable, and preferred futures. Ideas such as "Treat the earth well, it is not given to you by your parents, but loaned to you by your children" and human responsibility to ensure future well-being of all living things are explored. http://www.cpawscalgary.org/education/pdf/inventing-future.pdf



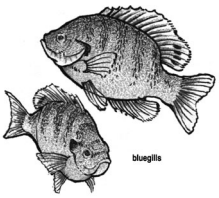
Futuristics: A time to come. By Joey Tanner, Zephry Learning Packet, 1991. This guide provides units for K-3 and 4-8 using an interdisciplinary approach to studying futuristics through understanding trends, making predictions, and developing creative solutions.

The Millenium Project: Global Futures Studies and Research. By the American Council for the United Nations University. This Web site links to extensive research and study of the future including scenarios developed for different themes, indicators developed to measure progress, and sources of further information. The site may be useful to research current efforts, on a global scale, to plan for the future. Visit: http://www.acunu.org/

Future Problem Solving, UNESCO Teaching and Learning Program 23. Programs engage middle and high school students in future-thinking and are sponsored by local school districts nationwide and globally. Information is available at: http://www.unesco.org/education/tlsf/theme_d/uncofrm_d.htm or search the Web for state or local organizations. ❖

Water Education Resources

A comprehensive listing of Wisconsin's Community Water Education and Action Opportunities including programs like Project WET, Water Action Volunteers, Give Water a Hand, Educating Young People About Water, and Adopt-A-Lake can be found on the Department of Natural Resources' Web site at: http://www.dnr.state.wi.us/org/caer/ce/bureau/education/reslst.htm



Grants and Awards

Environmental Grantmaking Foundations 2003. A catalog of foundations available in print and CD-ROM. Resources for Global Sustainability, Inc., P.O. Box 3665 Cary, North Carolina 27519-3665, (800) 724-1857, e-mail: rgs@environmentalgrants.com, or visit: http://www.environmentalgrants.com

Edith Stevens Groundwater Educator Award. Recognizes educators who understand the importance of groundwater, motivate others to protect groundwater, and lead by personal example. Anyone actively involved with the implementation and delivery of groundwater education programs is eligible. Nomination Deadline: July 14th annually. Visit: http://www.groundwater.org/Awards/Edith_Stevens.htm

National Environmental Education and Training Foundation (NEETF). NEETF supports a wide array of EE efforts: research, conferences, training, communications, and programs for all ages. Challenge grants focus on the areas of health, drinking water, business and educational excellence. An analysis of EE opportunities in the No Child Left Behind Act is also found at: http://www.neetf.org/

The Watershed Initiative. Designed to encourage successful community-based approaches to restore, preserve, and protect the nation's watersheds. This new competitive grant program is a bold approach to watershed management in that it will provide needed resources to those watershed organizations whose restoration plans are ripe, and who are anxious to achieve quick, yet tangible environmental change. This year, Congress appropriated $15 million for the Initiative and it is anticipated that funding will continue given presidential support. Grants will range between $300,000 to $1 million. Visit: http://www.epa.gov/owow/watershed/initiative/ ❖

Books, Magazines, Posters

Blue Gold: The Fight to Stop the Corporate Theft of the World's Water. By Maude Barlow, Tony Clarke Blue Gold shows why, as the vice-president of the World Bank has pronounced, "The wars of the next century will be about water." The consumption of water doubles every 20 years-more than twice the rate of the increase in human population. Blue Gold captures in striking detail the forces behind the increasing depletion of the world's fresh water, and the human and ecological impacts.

Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems. A Great Lakes curriculum guide will highlight the real-life impacts of climate change on students' home states and familiar environments, exploring in depth the ecosystem goods and services upon which our human economy depends; and, emphasize practical solutions that will both mitigate future harm and help us adapt to those changes that are inevitable. A fact sheet provides an easy reader which briefly outlines climate projections for Wisconsin, potential impacts on water supply, lakes, streams, wetlands, wildlife, and solutions. Visit the Web site to sign up to be notified when the guide is available at: http://www.ucsusa.org/greatlakes

Water Follies: Groundwater Pumping and the Fate of Americas Fresh Waters. By Robert J. Glennon. Glennon describes the culture of water use in the United States, explaining how and why we are growing increasingly reliant on groundwater using a collection of case studies from the arid west to the humid southeast. These stories bring to life the human and natural consequences of our growing national thirst and reliance on groundwater.

Wisconsin Natural Resources Magazine Supplements. (1999, Groundwater: Protection Wisconsin's Buried Treasure (PUBL-DG-055), Feb. 2003, Storm water runoff; April 2003, Lake Superior; June 2003 Nonpoint source redesign; watch for the April 2004 issue on Coastal beaches). Visit: http://www.wntmag.com/ or call (800) 678-9472. ❖

Instructional Materials

El Agua Es Importante: guia de maestro sobre recursos de agua, Volumen 3. These educational materials, written in Spanish, include a teacher's guide and a set of posters created by the U.S. Geological Survey's Water Resources Education Initiative. El Agua Es Importante, Volumen 3 is designed to help primary and middle school teachers satisfy the National Science Education Standards and provides background information and suggestions for activities to heighten student interest and promote query-based, hands-on learning. Topics covered include oceans and coastal hazards, watersheds, and hazardous waste. Cost: Free. Order Publication Number: 171-K-02-001 from the U.S. Environmental Protection Agency's National Center for Environmental Publications at 1-800-490-9198 or online from the EPA Web site at: http://www.epa.gov/ncepihom/ordering.htm

Groundwater Sand Tanks. Are you interested in borrowing a groundwater sand tank model for your school? Check out this list of groundwater models available for loan on the DNR Groundwater Education Resources Web page at: http://www.dnr.state.wi.us/org/water/dwg/gw/educate.htm

The Water Sourcebooks. By the Environmental Protection Agency. The books contain 324 activities for grades K-12. This environmental education program explains the water management cycle using a balanced approach showing how it affects all aspects of the environment. Activities are available online in PDF and are also available on CD-ROM. To order the CD, call (800) 424-4372 or send an email to haertel.jan@epa.gov. For more information about this free resource visit: http://www.epa.gov/safewater/kids/wsb/*

The Earth Day Network. Water-related lesson plans are available in An Educator's Guide to Water Quality. An online version can be found at http://www.earthday.net/goals/clean_water.stm.

POW! The Planning of Wetlands: An Educator's Guide. By Environmental Concern Inc. Build a wetland with your students and take wetlands education to a new level. Turn your schoolyard into a wetland discovery zone. This program consists of 25 hands-on activities that allow students in grades five through twelve to fully participate in designing, preparing and monitoring their planned wetlands. Courses are available. Contact Environmental Concern Inc. at (410) 745-9620 or log-on to: http://www.wetland.org

Rain Gardens. By University of Wisconsin-Extension and Wisconsin Department of Natural Resources. Rain gardens are catching on in popularity as landscaping options. Learn how rain gardens help protect water quality, and step-by-step instructions on how to build a rain

garden in your yard. Download the publication from the UW-Extension Web site at: http://cleanwater.uwex.edu/pubs/raingarden/

Slow Down in Town: From backyards to business and city hall. By the Wisconsin Department of Natural Resources, Wisconsin Natural Resources Magazine. This in- depth primer describes how people in town can curb storm water pollution by using simple techniques such as rain gardens, detention ponds, and trenches. Some of these methods can also help wildlife at the same time. Available online at: http://www.wnrmag.com/supps/2003/feb03/run.htm

Yard Care & the Environment Series. By UW-Extension Service. A series of water quality fact sheets is available for residential areas including school yard care practices. Download the publications online from: http://cleanwater.uwex.edu/pubs/ ❖

Web Resources

EEK! Environmental Education for Kids:
http://www.dnr.state.wi.us/eek/
This electronic magazine is for kids in grades four through eight and contains information on water critters, water issues facing Wisconsin today, and the water cycle.

Wisconsin Lakes Partnership:
Youth and Lakes
http://www.dnr.state.wi.us/org/water/fhp/lakes/lkyouth.htm

Lakes Education Publications:
UW-Extension Lakes Program
http://www.uwsp.edu/cnr/uwexlakes/publications/

NatureNet :
http://www.naturenet.com/index.html
Nature Net is "one-stop shopping" for environmental education resources for teachers and families of south-central Wisconsin and beyond! Check out their resource listing by subject and find links to information on aquatic habitats, groundwater and watersheds, water quality and protection, and more.

Water Quality Association:
http://www.wqa.org/
This water Web site is geared for the professional water provider as well as consumer. It provides current water issue headlines around the world and also contains a useful water information library where students can search for information on topics from bottled water to lead in drinking water.

"Year of Freshwater" Web page for kids:
http://www.dnr.state.wi.us/org/caer/ce/eek/earth/yearofwater.htm

What's Up With Our Nation's Waters?
http://www.epa.gov/owow/monitoring/nationswaters/

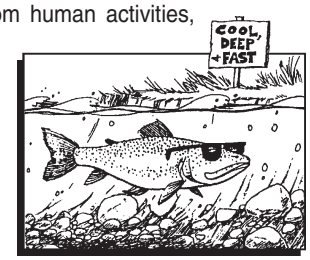
Wisconsin Year of Water:
http://www.wisconsinyearofwater.org/

Listings of educational resources,
other Web sites,
Wisconsin Department of Natural Resources' Year of Water educational Web site: http://www.dnr.state.wi.us/org/water/yow/index.htm ❖

Water Events

September 10-12. *Lake Superior Water and Land Symposium.* Bad River Casino and Conference Center, Odanah. Three workshops cover how to protect and restore the natural resources around Lake Superior, the world's largest freshwater lake basin. Contact Lissa Radke, Lake Superior Binational Forum, (715) 682-1489, or e-mail: lradke@northland.edu

September 12. *Living on the Edge: Protecting and Restoring Lake Superior's Rivers and Streams.* Bad River Casino and Conference Center, Ashland. Learn how streams and rivers work, impacts from human activities, successful restorations, education tools, and use of GIS to reduce impacts. Contact Lissa Radke, Lake Superior Binational Forum, Northland College, 1411 Ellis Ave, Ashland, WI 54806, call (715) 682-1489, e-mail: lradke@northland.edu, or visit: http://www.superiorforum.info



September 20. *Wisconsin River of Words: Connecting Kids with their Watersheds through Poetry and Art.* Treehaven Field Station, Tomahawk. (9 A.M.-4 P.M.) Using Wisconsin River of Words (ROW) program materials, discover techniques to interest K-12 children in expressing their views of nature through words and images. ROW is a national art and poetry program focusing on watersheds, brought to Wisconsin by the UW-Extension Lakes Program and the Wisconsin Center for the Book. Open to all educators, this workshop will supply you with knowledge about your specific watershed and creative activities to get kids to turn their observations of nature into works of art. Limited to 25 participants. Cost $50 includes materials and lunch. Limited Friday lodging available for an additional $30. Six DPI clock hours. Contact Mary at (715) 346-4978, or register online at: http://www.uwsp.edu/cnr/uwexlakes/row/

September 20-21. *Third Annual Crane Festival. Necedah National Wildlife Refuge, Necedah.* Whooping Cranes require wetland habitat, come and learn about them and see them in a fly-over behind an ultra-light aircraft. Enjoy this fair atmosphere, with art and craft activities and booths, food, refuge tours, guest speakers, and fun activities. Contact Molly Mehl at (608) 565-4409, or e-mail: molly_mehl@fws.gov

September 24-26. *Annual Meeting of the Wisconsin Water Association.* Middleton Marriot, Middleton. This group represents about 1000 members involved in the Wisconsin drinking water community. The theme focuses on "Wisconsin Year of Water 2003." Contact Mike Rau (414) 221-3020 or Jack Albrechtson (608) 831-6554.

September 27. *Wisconsin River of Words: Connecting Kids with their Watersheds through Poetry and Art.* Great Blue Peace Camp, Hudson. (9 A.M.-4 P.M.) (See description for September 20) Limit of 15 participants. Cost: $45 includes materials, bring lunch. Contact Mary at (715) 346-4978, or register online at: http://www.uwsp.edu/cnr/uwexlakes/row/

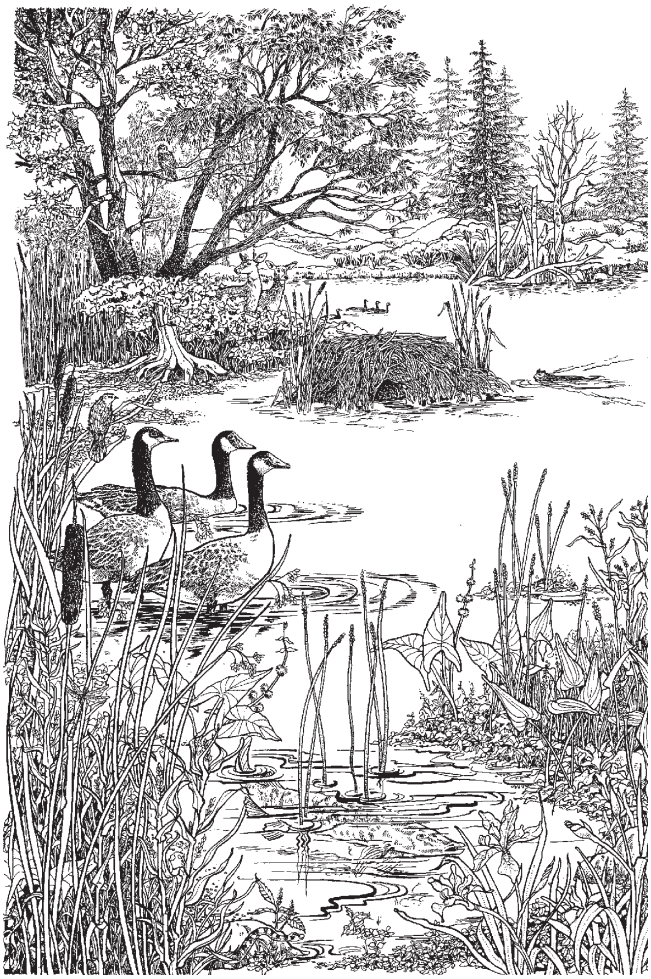
September 29. *Wisconsin Natural History Series - No. 1.* Treehaven, Tomahawk. (10 A.M.-4 P.M.) Spend a fall day at Treehaven learning about the ecology of the Wisconsin River, enjoying a short hike, and learning about endangered species in our State. Cost: $15, includes lunch. Contact John Heusinkveld, W2540 Pickerel Creek Avenue, Tomahawk, WI 54487, call (715) 453-4106, or e-mail treehaven @uwsp.edu, visit their Web site at: http://www.uwsp.edu/cnr/treehaven

October 18. *Wisconsin River of Words: Connecting Kids with their Watersheds through Poetry and Art.* Whitefish Dunes State Park, Sturgeon Bay. (9 A.M. - 4 P.M.) (See description for September 20) Cost: $35 includes materials, bring lunch. Note: park sticker required for park entrance or purchase a $5 day pass. Contact Mary, (715) 346-4978 or register online at: http://www.uwsp.edu/cnr/uwexlakes/row/

November 8. *Project WET.* Havenwoods, Milwaukee. (9 A.M.-3:30 P.M.) This international interdisciplinary water education program is for formal and nonformal elementary educators. Learn about the program, participate in activities, and receive an activity guide with over 90 interdisciplinary water resource activities. Cost: $30/person. Register through Havenwoods, 6141 N Hopkins, Milwaukee WI 53209-3565, call (414) 527-0232, by October 29.

December 10. *2003 Governor's High School Conference on the Environment.* The Wisconsin Center for Environmental Education invites students and teachers, grades 9-12 to explore understanding and appreciating water, investigate water issues, and develop community participation skills to care for and use water. This year's theme is Pooling Our Resources: Understanding and Protecting Water in Wisconsin. The Governor is invited as keynote speaker. Each school can bring up to eight students who are "ambassadors" and present a group poster session and attend workshops, gathering information and ideas to share with classmates. Students with an active interest in the environment and leadership potential are encouraged to attend as a school group, individuals, or with other organizations. For registration information visit:http://www.uwsp.edu/cnr/wcee/youthconference/index.htm, or contact Deborah Engel-Di Mauro at (715) 346-3604 or e-mail: dengeldi@uwsp.edu. Registration is first-come, first-served with priority registration until October 10. Final registration deadline is November 14. ❖

Wisconsin: My Father's Promised Land



Wisconsin Lakes Partnership, Carol Watkins, artist

In loving memory of
Roosevelt Lorenzo Garrett

When my Daddy had had enough,
He'd pack his rods and reels and stuff.
Off to his precious Wisconsin he would escape.
To a place where he could be honest, open and relate.
My Daddy often spoke of this beautiful promised land.
Where the air was sweet and clean; the trees stood so grand.
The majestic lighthouses and the breathtaking waterfalls,
The movement of the streams where he could hear old man river call.
Where he could sit by the lakes, so crisp, so cold
Paused by the edge of the crystal clear waters with his fishing pole.
My Daddy said Wisconsin was an incredible place,
Where the unobstructed sunshine beams could kiss his face.
The moon was as bright as an opal in the sky at night.
The stars that twinkled like dancing holiday lights
He would talk to the healing waters for his spirit and his mind
Let his heart synchronize its beats with nature's time.
He meditated by the Wisconsin River to calm his soul
He flowed back to his youth in his thoughts so he never grew old.
This magical kingdom located between the Mississippi River and the Great Lakes
He picked Wisconsin as his refuge; it was not a mistake.
The noise and distraction of the city would cease,
For here, in Wisconsin, he found freedom, solace and peace.

October 21, 2002. Deborah Garret Thomas, a poet with African and Native American ancestry, is a wife, mother, and grandmother whose love of family is a central theme in her work.